

Effect of Good Hygiene Practices Intervention on Food Safety in Senior Secondary Schools in Ghana

- [P.F. Ababio^{a,b,.}](#),
- [K.D.A. Taylor^a](#),
- [M. Swainson^a](#),
- [B.A. Daramola^a](#)

• ^a University of Lincoln, College of Sciences, National Centre for Food Manufacturing, Park Road, Holbeach, Spalding PE12 7PT, UK

• ^b University of Education, Winneba, Kumasi Campus, Catering and Hospitality Department, Box 1277, Ghana

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Highlights

- Good hygiene practices intervention in the form of training improved kitchen staff hygiene awareness scores.
- Staff temperature and time monitoring for ready to eat (RTE) meals' significantly improved after training.
- Microbiological contaminants (ACC, coliforms, yeast and moulds, *Staphylococcus aureus* and *Bacillus cereus*) in RTE meals reduced with a significant reduction in Aerobic Colony Count (ACC) and *Staphylococcus aureus* levels after training.

Abstract

Eleven schools in three different hygiene categories were given hygiene training as an intervention to reported low hygiene standards. Staff hygiene knowledge scores, food temperature, food service time and microbiological quality of jollof rice (cooked rice in tomato sauce and fish) were measured before and after the intervention. Descriptive statistics and Wilcoxon's Signed- Rank Test for repeated measures on SPSS were used to evaluate the effect of GHP intervention. Staff hygiene knowledge and practice scores, food temperature, aerobic colony count (ACC) and *Staphylococcus aureus* load in ready to eat (RTE) meal improved significantly ($p \leq 0.05$). Food hygiene training remains an essential legal and industrial requirement.

Keywords

- Good hygiene practices (GHP);
 - Intervention;
 - Training;
 - Ghanaian schools;
 - meals;
 - Food safety
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1. Introduction

Good hygiene practices (GHP) are the procedures and practices undertaken with the use of best practice principles ([British Retail Consortium, 2011](#)). European Commission (EC) Regulation No 853/2004, defines food hygiene as the measures and conditions necessary to control hazards and to ensure fitness for human consumption of a food stuff taking into account its final use ([EU, 2004](#)). GHP are generally called the prerequisite measures upon which other Food Safety and Quality Management Systems are built. They include an exhaustive list of measures and among them is staff personal hygiene and training. Food hygiene training is a legislative requirement ([World Health Organisation/Food and Agriculture Organisation, 2009](#), [Food and Drugs Authority, 1992](#) and [Food Standards Agency, 2009](#)) that ensures that safety practices are used and maintained in food preparation environment. Whilst some authors including [Osimani et al \(2011\)](#), [Santana et al \(2009\)](#), [Youn and Sneed \(2003\)](#), [Hwang et al \(2001\)](#) and [Bryan et al \(1992\)](#) have reported positive association of training protocols with good hygiene practices of trainees, others including [Soares et al \(2012\)](#), [Eghan et al \(2007\)](#), [Kwon \(2003\)](#) and [Ehire et al 1996](#)) have reported otherwise, thus the lack of conclusive evidence that staff hygiene training has an effect on their practices. Some of the factors blamed for lack of success in hygiene training were methods used, demographics of trainees and their preparedness to learn, lack of supervision after training, absence of refresher programmes and lack of resources to implement knowledge gained in areas with economic challenges ([Gilling et al 2001](#)). [Feglo et al \(2004\)](#) recommended training and surveillance to be paramount in areas where due to cost, the establishment and designing of acceptable infrastructure and utilities could take ages to ensue. [Tomlins et al, \(2002\)](#) [Mensah et al, \(2002\)](#), [Taylor et al \(2008\)](#), [Sneed et al \(2004\)](#), [Adolf and Aziz \(2012\)](#) and [Feglo and Sakyi \(2012\)](#) equally highlighted the importance of hygiene training in the food industry. The researcher sought to investigate the effect of GHP training on hygiene knowledge and practices of Senior Secondary

School kitchen staff in Ghana and the direct implication on food safety microbiologically.

2. Methodology

Eleven schools were sampled (4 good, 4 medium and 3 poor hygiene category schools) out of an originally hygiene audited 45 schools from the Ashanti Region of Ghana (Figure 1) and coded from OO1- O45. This region was the most populated region in the country, a central trading zone prone to food borne diseases (Osei, 2010) with low level of food hygiene education. The region enrolled 44.1% of the 2008/2009 Senior High School (SHS) students in the country and holds approximately 18% of the 700 public SHS's in the country (MoE, 2009, Siaw and Nortey, 2011).

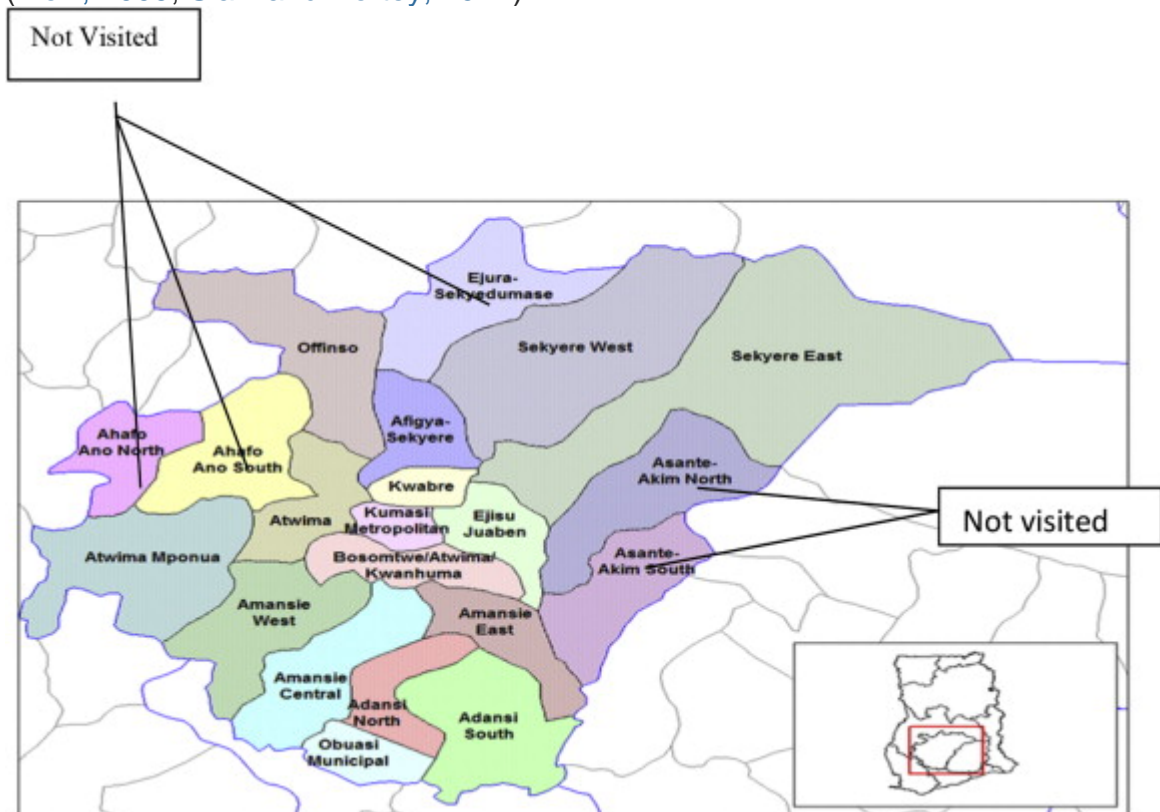


Fig. 1.

The Ashanti Region of Ghana (Wikipedia, 2006).

Figure options

2.1. School Pre training Visits

Approval letters from the Regional Director of Education were sent to heads of institutions for permission to conduct the study by the researcher. Forty five (45) head teachers in the schools permitted the researcher to visit their school kitchens between July and September of 2013. Schools were audited and placed under good, medium or poor hygiene category with an adopted check

list from [Santana et al \(2009\)](#). There were no excellent or very poor hygiene categories among the sampled schools. Kitchen staff food hygiene knowledge and practices were scored on a checklist. Food hygiene practices including temperature and time management of cooked ready to eat food (RTE) were also monitored during subsequent visits. Food and environmental sampling for microbiological analysis were also conducted.

2.2. Training on GHP

Twelve (12) schools out of the 45 were sampled for the training with 4 from each hygiene category. One school dropped out after the first visit hence 11 schools were available for the training. GHP training in the schools took between 3 and 4 hours per school. The researcher arranged training dates with the matrons who then prepared their staff for the day. Domestic Bursars and their matrons provided seating space for the training on these visits.

Training materials used during training included;

i.

Power- Point presentation on the overall audit outcome from the 45 schools visited, GHP as a legal requirement of the National Food Law (PNDCL 305B) and reported cases in the media on food poisoning and food borne diseases in the country and specifically from SHS's.

ii.

A video presentation on Safer Food Better Business Version 3 ([FSA, 2009](#)) which touches on the 4C's (Cross contamination, Cleaning, Cooking and Chilling) were shown.

iii.

Demonstrations on effective hand washing with trainee participation was done with the help of Pro-Clean, a rapid protein food residue test kit from Hygiena-UK for before and after effect on effective hand washing and cleaning of food contact surfaces ([Plate. 1](#)).



Plate 1.

Hygiena Pro-Clean™ for rapid protein food residue test-colour indicating good and poor cleaning status of swabbed surface.

Figure options

iv.

4 kitchen staff from each school were randomly selected from each school and assessed on knowledge acquired before and after the training.

2.3. Food sample collection and microbiological assessment of ready to eat meals

Two replicates of 100g of jollof rice (rice cooked in tomato sauce and fish) and where not available, other rice meals like 'wakye' (cooked rice and beans) or plain rice were aseptically collected into sterile stomacher bags from schools between after cooking and students meal time. Samples were kept on ice in ice chest and transported to the laboratory for analysis within 4 hours of collection. Time of collection and temperature of food at collection time were also recorded. Food samples from each school were thoroughly mixed and 25g of the mixture was homogenised in 225ml of buffered peptone water (BPW) using a stomacher set at 200rpm for 2 minutes. Serial dilutions from 10^1 to 10^6 were prepared and 0.1ml portion from each serially diluted samples were then inoculated in duplicates onto appropriate freshly prepared culture media. Plate Count Agar (PCA) was used for aerobic colony count (ACC) at $30^\circ\text{C} \pm 1$ for 72 ± 3 hours (ISO, 2003, Sospedra *et al* 2013). MaCkonkey agar was used for coliforms at 37°C for 48 hours. Dicloran rose-bengal chloramphenicol (BAM, 2001) was used for yeast and mould at 25°C for 5 days in dark environment and Baird-Parker agar with egg yolk tellurite (Santana *et al* 2009, Sospedra *et al* 2013) was used for *Staphylococcus aureus* at 37°C for 48 hours. *Bacillus cereus* agar with added egg yolk emulsion and polymyxin B was used for *Bacillus cereus* at 37°C for 24 hours (Blackburn and McClure, 2009).

Plates with 20-200 typical colonies of individual microorganisms were selected and counted. Randomly selected colonies on individual culture media were also selected for biochemical test and confirmation. Typical colonies of presumptive *S. aureus* were aseptically inoculated on Brain Heart infusion (BHI) broth and emulsified, the suspensions were incubated at 35 °C for 18-24 hours. Coagulation was conducted with 0.5ml of reconstituted coagulase plasma added to the BHI culture and incubated at 35 °C and observed. Gram staining, microscopy, catalase test and API Staph. were used to confirm the presence of coagulase positive *S. aureus*. Microscopy, oxidase test and motility test were similarly conducted for *Bacillus cereus* presence using typical blue colonies with halo zone of egg precipitate. Counted colonies were then used for calculation of Colony Forming Unit per gram (CFUg⁻¹) for each sample. Mean CFUg⁻¹ were converted to logs for statistical analysis. Tests were repeated after GHP training for the 11 schools and data were then compared. Laboratory work begun in December 2013 and ended in July 2014.

2.4. Statistical Analysis

Descriptive statistics, general linear model and Wilcoxon's signed-rank test for repeated measures on SPSS Version 21 were used to analyse data on the effect of GHP training on staff hygiene practices at 95% confidence interval.

2.5. Microbiological criteria for cooked rice and other farinaceous foods in Ghana using Ghana Standards Authority (GSA) standard GS 955:2013

The Ghana Standard Authority (2013) established criteria for ACC, *B. cereus*, *S. aureus*, total coliforms and yeast and moulds for cooked rice and related meals ([Table 1](#)) was used as the acceptability criteria for the microbiological analysis of jollof rice from the schools. [Table 2](#)

Table 1.

Microbiological limits (CFUg⁻¹) adopted for the definition of acceptability of food.

Food	ACC	Total Coliforms	Yeast and Moulds	<i>Staphylococcus aureus</i>	<i>Bacillus cereus</i>	Salmonella
Cooked and ready to eat meal	10 ⁴	10 ²	10 ³	10 ²	10 ²	Absence in 25g

Table options

Table 2.

Back ground information on 180 kitchen staff from 45 SHSs in Ashanti Region of Ghana in percentages.

Respondents in percentages						
Gender	Males6.7			Females93.3		
Age	19-29 years	30-39 years	40-49 years	50-59 years	60 years	Can't remember
	10.6	24.4	35.0	29.0	0.5	0.5
Years of work experience	1-5 years	6-10 years	11-15 years	16-20 years	>20 years	Can't remember
	30.0	33.0	13.0	4.0	19.0	1.0
Staff Roles in Kitchen	Cooks	Pantry/Servers	Team leaders	Supervisors	Matrons	Can't remember
	50.6	5.6	42.2	1.6	0.0	0.0
Academic qualification	None	Basic	Secondary/Advanced catering	Higher National Diploma	First Degree	Second Degree
	10.0	70.0	17.8	2.2	0.0	0.0
Hygiene Trained	Yes			No		
	9.4			90.6		
Happy to receive training	Yes			No		
	97.2			2.8		
Table options						

Table3.

Effect of GHP Intervention on food and personal hygiene scores.

School	Code	PreFHK scores%	PostFHK scores%	PrePHR scores%	PostPHR scores%
Poor	oo1	42.8	74.8	67.5	83.0
	oo4	34.5	98.3	60.8	73.8
	o20	36.5	80.3	61.0	74.3
Mean		37.9 ±4.3	84.4± 12.3	63.1± 3.8	77.0±5.2
Medium	oo2	38.0	78.0	77.8	83.3
	oo3	49.5	76.5	89.0	85.0
	oo5	24.8	89.8	68.8	81.3
	o12	31.4	59.5	67.3	78.0
Mean		35.9±10.8	75.9±12.5	75.7±10.1	81.9±3.0
Good	oo7	28.0	73.0	72.3	84.0
	o10	44.7	66.5	74.0	91.5
	o19	31.3	78.0	69.0	81.5
	o26	23.3	76.0	59.5	88.3
Mean		31.8±9.2	73.4±5.0	68.6±6.5	86.3±4.4
Schools Mean		34.9±8.3	77.3±10.3	69.7± 8.6	82.2±5.4

FHK- Food hygiene knowledge, PHR- Personal hygiene scores.

Table options

Table 4.

Effect of GHP intervention on food temperature (°C) and time (min.) control across hygiene categories.

Hygiene Category	Schoolcode	Pre training food temp. °C	Pre training Food waiting time/min	Post training Food Temp/°C	Post training Food waiting time/min
Poor	oo1	68.00	100.00	69.50	45.00
	oo4	55.00	60.00	61.00	35.00
	o20	55.50	27.50	73.50	97.50
Mean		59.50±7.37	62.50±36.31	68.00±6.38	59.12±33.57
Medium	oo2	49.50	35.00	73.0	25.50
	oo3	65.00	120.00	66.00	25.00
	oo5	54.50	35.00	61.00	30.00
	o12	57.50	75.00	66.50	45.00
Mean		56.68±6.51	66.25±40.49	66.63±4.92	31.38±9.36
Good	oo7	69.50	36.50	66.00	55.00
	o10	59.50	57.50	77.50	45.00
	o19	61.50	60.00	60.00	55.00
	o26	68.50	30.00	77.00	20.00
mean		64.75± 4.99	46.00±14.99	71.38±6.81	43.75±16.52
Schools mean		60.36±6.66	57.86±30.23	68.73±5.83	43.45±21.59

Table options

Table 5.

Effect of GHP intervention on microbiological contaminants in food.

Microbial counts in Log₁₀CFUg⁻¹

Hygiene Category	School code	Pre AC C	Post AC C	Pre Coliforms	Post Coliforms	Pre Yeast and moulds	Post Yeast and moulds	Pre S. aureus	Post S. aureus	Pre B. cereus	Post B. cereus
poor	oo1	6.60	2.24	6.03	2.22	3.74	2.72	4.31	2.00	5.11	2.00
	oo4	5.75	3.63	2.80	2.74	2.00	2.43	5.22	2.65	3.65	2.50
	o20	3.09	4.04	2.50	3.62	3.00	2.00	3.22	2.50	3.50	3.91
Mean		5.15 ±1.83	3.30 ±0.94	3.78 ±1.95	2.86 ±0.70	2.91 ±0.87	2.38 ±0.36	4.25 ±1.00	2.38 ±0.34	4.09 ±0.89	2.80 ±0.99
Medium	oo2	4.19	3.44	3.35	3.14	3.83	2.09	3.80	2.00	3.15	4.52
	oo3	5.81	2.65	3.07	2.00	2.65	2.15	4.12	2.00	3.47	3.54
	oo5	3.69	2.69	2.52	3.04	2.91	2.00	2.54	2.00	2.96	3.78
	o12	5.30	3.26	4.52	2.66	2.15	3.40	3.82	2.00	4.15	2.15

Microbial counts in Log₁₀CFUg⁻¹

Hygiene Category	School code	Pre AC C	Post AC C	Pre Coliforms	Post Coliforms	Pre Yeast and moulds	Post Yeast and moulds	Pre <i>S. aureus</i>	Post <i>S. aureus</i>	Pre <i>B. cereus</i>	Post <i>B. cereus</i>
Mean		4.75 ±0.97	3.01 ±0.40	3.37 ±0.84	2.71± 0.52	2.89 ±0.70	2.41 ±0.66	3.57 ±0.71	2.00 ±0.00	3.43 ±0.52	3.49 ±0.99
Good	oo7	5.24	3.02	5.15	4.00	2.65	3.31	3.94	2.00	2.30	3.18
	o10	2.99	4.00	2.99	2.65	2.27	2.00	2.15	2.00	2.27	2.33
	o19	3.00	3.45	2.59	2.50	4.10	2.00	2.77	2.24	2.86	2.00
	o26	3.92	3.04	3.31	2.41	3.47	2.15	2.00	2.00	2.78	2.00
Mean		3.74 ±1.06	3.38 ±0.46	3.51 ±1.13	2.89 ±0.75	3.12 ±0.82	2.36 ±0.63	2.71 ±0.88	2.06 ±0.12	2.55 ±0.31	2.38 ±0.56
Schools mean		4.51 ±1.28	3.23 ±0.57	3.53±1.18	2.82 ±0.59	2.98 ±0.72	2.39 ±0.53	3.44 ±0.99	2.13 ±0.24	3.29 ±0.83	2.90 ±0.92

Table options

3. Results and Discussion

3.1. Kitchen Staff demographics

Kitchen staff in the Ashanti Region of Ghana were predominantly females which support reports by [Tomlins *et al*, \(2002\)](#), [Mensah *et al*, \(2002\)](#) and [Ababio and Adi \(2012\)](#). Basic education qualification was the highest academic level (20%) amongst the workers ([Table 1](#)). There were also 10% staff who had no formal education working in the kitchens.

Higher National Diploma (HND) was the highest qualification and only 2.2% staff in supervisory positions had this. Only 10% had no formal education which was contrary to the report published by [Mensah *et al* \(2002\)](#) on food vendors in Accra where 33.3% had no formal education. The highest age range was 40-49 years (35%) with only a few young people between the ages of 19-29 (12%). Staff who had worked in kitchens for 1 to 10 years were the highest group (66%). Those who had worked more than 20 years (19%) were also more than those with 11 to 20 years' experience (17%). Surprisingly 90.6% of the kitchen staff had never had any hygiene training since they began preparation of food for students within their 1 to more than 20 years of work experience. This

supports Taylor *et al* (2008) who reported that workers in small scale enterprises and welfare hospitality (including schools) mostly had no work related training and based food safety standards on experiences, common sense and luck instead of established standardised procedures. Almost all staff (97.2%) were happy to receive the GHP training as they believed it would help them to improve on their knowledge and current hygiene practices.

3.2. Effect of GHP training on staff hygiene knowledge and practice scores

Food hygiene knowledge scores increased substantially and significantly (Table 6) across the categories with percentage mean difference of 44%, 40% and 42% for poor, medium and good hygiene category schools clearly indicating that knowledge acquisition had taken place as all the schools failed (<50%) in the initial test (Table 3). Personal hygiene knowledge scores equally significantly improved after training with 14%, 11% and 29% mean score increase for poor, medium and good hygiene category schools. This supports Sneed and Henroid (2007) and Santana *et al* (2012) who reported on a positive effect of training on school kitchen employees studied in US and Brazil respectively. Youn and Sneed (2003) in their study on the impact of educational interventions on the implementation of HACCP in US reported that food safety knowledge of the sampled staff was high but also increased at post training test ($67.6 \pm 14.4 - 87.0 \pm 9.7$, $p=0.0001$). On the contrary the staff in the current study in Ghana had low FHK scores before the training which significantly increased ($p \leq 0.05$) after training. This could be due to the absence of previous training as 90.5% of staff in these schools reported not to have had any GHP training at their work place (Table 1).

Table 6.

Comparing effect of GHP intervention on staff hygiene knowledge and practices using Wilcoxon's signed-rank test ($p=0.05$).

Variables	N	Z	p(1- tailed)
Pre- post FHK	11	-2.934	0.001*
Pre- post PHR	11	-2.847	0.001*
Pre-post food temp.(°C)	11	-2.625	0.003*
Pre-post food waiting time(Min)	11	-1.512	0.070
Pre- post ACC	11	-1.956	0.027*
Pre -post Coliforms	11	-1.778	0.042*
Pre -post Yeast and moulds	11	-1.689	0.051
Pre- post <i>Staph. spp</i>	11	-2.803	0.001*
Pre- post <i>Bacillus cereus</i>	11	-0.533	0.319

Table options

Food hygiene knowledge and practices that improved included avoidance of jewellery during food preparation, hair covering, hand washing with soap, reduced talking during food preparation, knowledge on reporting infectious diseases, importance of temperature and time control, washing of work cloths and uniforms daily, the use of warm water and soap to clean food contact surfaces and some food pathogens and diseases they cause.

3.3. Effect of GHP training intervention on RTE meal temperature and time control

The mean temperature for jollof rice in the Ghanaian schools during service at Pre GHP training was below 63.0 °C with the exception of good hygiene category schools which had a mean temperature of 64.8 °C \pm 4.99 with a food waiting time of 46.0 \pm 14.99 minutes ([Table 4](#)) After GHP intervention medium hygiene category schools improved with mean temperature difference of 10 °C and a mean time difference of 35 minutes. Good hygiene and poor hygiene category schools equally increased the temperature of food but with only slight reduction in waiting time after dishing. School O20 recorded longer waiting times than before GHP intervention. This was because the matron was absent during the weekend and staff practice in the absence of a matron was to hurry with their chores and leave for their various homes. Indicating that in the absence of supervision, what personnel have learnt might not be put into use ([Gilling *et al* 2001](#)).

This necessitates the presence of food safety trained personnel or hygiene trained assistant matrons to take up monitoring and supervision role in the absence of the matron/manager and during weekends. The general increase in overall schools food mean temperature from 60.4°C - 68.7 °C and reduced waiting time of cooked food from 57.9 – 43.5 minutes indicated a change. This Post GHP temperature was significantly different from Pre GHP temperature ($p<0.05$) although Pre-post GHP time were not significantly different ([Table 6](#)). [Osimani *et al* \(2011\)](#) reported of progressive non-conformities reduction from 55% to 30% in a year through progressive temperature and time management after training. A significant improvement of temperature control in this report in the Ghanaian schools equally positively affected food safety ([Table 5](#)). [Santana *et al* \(2009\)](#) reported an increase in cooking and serving temperature after training for all categories with the exception of poor hygiene category school which had a serving temperature of 45.6 °C \pm 1.6 from 40.1°C \pm 1.7. The excellent category school in Brazil also had hot holding equipment for cooked ready to eat meals. From this current research none of the schools from Ashanti Region had hot holding equipment for cooked food.

Although jollof rice is processed at high temperature ($>80^{\circ}\text{C}$) that should kill vegetative cells, it could be cross contaminated from serving equipment and food handlers in a poor hygiene environment ([Mensah et al 2002](#)). Survival and regeneration of spores are also eminent if after cooking, temperatures are allowed to fall in an uncontrolled environment for longer periods before meals.

3.4. Effect of GHP intervention on microbiological contaminants in cooked RTE meal (jollof rice)

Cooked food mean microbial load in the schools reduced for all the organisms enumerated ([Table 5](#)). The national acceptable level of ACC in cooked food by GS 955:2013 (GSA, 2013) was $4 \text{ Log}_{10} \text{ CFUg}^{-1}$. After GHP intervention the schools (100%) had Post ACC load ranging from $2.24 - 4 \text{ Log}_{10} \text{ CFUg}^{-1}$ and a mean schools ACC of $3.23 \pm 0.57 \text{ Log}_{10} \text{ CFUg}^{-1}$ from Pre GHP record of $4.51 \pm 1.28 \text{ Log}_{10} \text{ CFUg}^{-1}$. Only school O20 from poor category exceeded this, but was only slightly above by $0.04 \text{ Log}_{10} \text{ CFUg}^{-1}$. [Mensah et al \(2002\)](#) had similar ACC count of $2.99 \text{ Log}_{10} \text{ CFUg}^{-1}$ in cooked rice sold by food vendors in Accra. The schools results were however less than the 5.48 ± 0.97 in macaroni sold in Kumasi of the Ashanti Region of Ghana ([Feglo and Sakyi, 2012](#)), but similar to $4 \text{ Log}_{10} \text{ CFUg}^{-1}$ reported by [Adolf and Azis \(2012\)](#) in rice meals from schools in Indonesia.

Santana *et al* (2012) recorded ACC Log reductions of 3.5, 0.2 and 0.5 for poor, medium and excellent hygiene school meals respectively as a result of GHP training. Schools from the Ashanti Region of Ghana in this study recorded 1.85, 1.74 and 0.36 Log reductions for poor, medium and good hygiene category schools respectively. This work thus supports Sneed and Henroid, (2007), [Hwang et al 2001](#) and Santana *et al* (2012) that food quality is improved with increased food hygiene knowledge.

The acceptable level for coliforms in cooked rice set by GS 955: 2013 (GSA, 2013) was $2 \text{ Log}_{10} \text{ CFUg}^{-1}$. School OO3 reached this criteria at Post GHP intervention with a 1.07 Log reduction. The overall schools mean was slightly above the national acceptable level although there was a mean reduction of $0.71 \text{ Log}_{10} \text{ CFU g}^{-1}$. The mean coliform count of $2.82 \pm 0.59 \text{ Log}_{10} \text{ CFUg}^{-1}$ in jollof rice after GHP was higher than the $1.5 \pm 2.04 \text{ Log}_{10} \text{ CFUg}^{-1}$ in rice sold by food vendors in Accra-Ghana by [Mensah et al \(2002\)](#) and could be reduced further. Other factors that could be sources of cross contamination including hands, utensils and ladles required attention as coliforms presence only indicated post cooking contamination. After GHP intervention all the hygiene categories had mean yeast and moulds levels within the national acceptable level of 3 Log in ready to eat rice meal in GS 955: 2013 (GSA, 2013). There were 82% schools

that met the national criteria. Current yeast and moulds levels were similar with the 3 Log₁₀ reported by [Adolf and Azis \(2012\)](#) from school meals in Indonesia. Further reduction in schools O12 and OO7 could help prevent the long term exposure effects of mycotoxin to the health of the students.

All the hygiene categories had mean reduction in *Staphylococcus aureus* count Post GHP intervention with 73% of the schools meeting the national criteria of 2 Log₁₀CFUg⁻¹ in GS 955: 2013 (GSA, 2013). There were no coagulase positive *Staphylococcus aureus* identified in jollof rice across the schools Post GHP intervention, this was similar to the Brazilian case after GHP training ([Santana et al 2009](#)). The Post GHP *Staphylococcus aureus* load, in all the good and medium hygiene category schools met the acceptable level with the exception of school 019 which was slightly over by 0.24 Log. Schools in poor hygiene category recorded a mean level of 2.38 ± 0.34 Log₁₀ CFUg⁻¹. Two schools out of this category had *Staphylococci* levels > 2 Log₁₀ <3Log₁₀ CFUg⁻¹. [Adolf and Azis \(2012\)](#) reported of 3.59 Log₁₀ CFUg⁻¹ of *Staphylococci aureus* in rice in Indonesian school meals which was higher than the Post GHP results from Ghana. Mean Log reduction in Brazilian schools after GHP for *S. aureus* was 1.1 which was similar to the 1.3 Log₁₀ from this report although the schools over all mean was slightly above the 2 Log₁₀ set by the GSA (2013) in GS 955: 2013. The schools mean *Bacillus cereus* in jollof rice reduced from 3.29 ± 0.83 to 2.90± 0.92 Log₁₀ CFUg⁻¹ Post GHP training. Three schools (27.3%) had the acceptable national level of 2 Log₁₀ CFUg⁻¹ (GS: 955, 2013) for *Bacillus cereus* in cooked rice meals Post GHP intervention. Both good and poor hygiene category schools reduced their Pre GHP *Bacillus cereus* levels by 0.17 and 1.29 Logs. Medium hygiene category schools did not reduce but had a slight increase of 0.06 Log CFUg⁻¹. *Bacillus cereus* levels generally were lowered at Post GHP and not up to toxin producing levels (>10⁵) that could cause food poisoning ([Blackburn and McClure, 2009](#)).

3.5. Comparing Pre-Post GHP data using Wilcoxon's signed rank test

There were significant differences (p≤0.5) between Pre-Post GHP food hygiene knowledge (FHK) and personal hygiene requirement (PHR) scores, Pre-Post GHP; food temperature, ACC, coliforms and *S. aureus* ([Table 6](#)) using Wilcoxon's signed-rank test for non-parametric repeated measures. There were improvements as hygiene knowledge and practice scores increased, temperature at service increased and microbiological contaminants (ACC, coliforms and *S. aureus*) significantly reduced after GHP intervention. There were however no significant difference in time (minutes) control, yeast and mould levels and *Bacillus cereus* in jollof rice from Pre-Post GHP intervention

although there were reductions with yeast and mould levels meeting the national acceptable level. [Santana *et al* \(2009\)](#) who used visual inspection check list in Brazilian schools equally reported of better scores with poor and medium hygiene category schools classified as good hygiene category schools and the excellent hygiene category school scores also increasing after GHP adoption.

4. Conclusion

All the Ghanaian schools improved in their knowledge and hygiene practices Post GHP intervention. Microbiological contaminants in food equally reduced Post GHP. There was enough evidence using Wilcoxon's signed rank test for repeated measures that GHP intervention improved hygiene knowledge and practices which positively affected food safety. This supports the importance of hygiene training for food handlers.

Uncited references

[Ehiri and Morris, 1996](#); [Taylor, 2008](#).

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Corresponding author. Tel.: 07400006200.

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